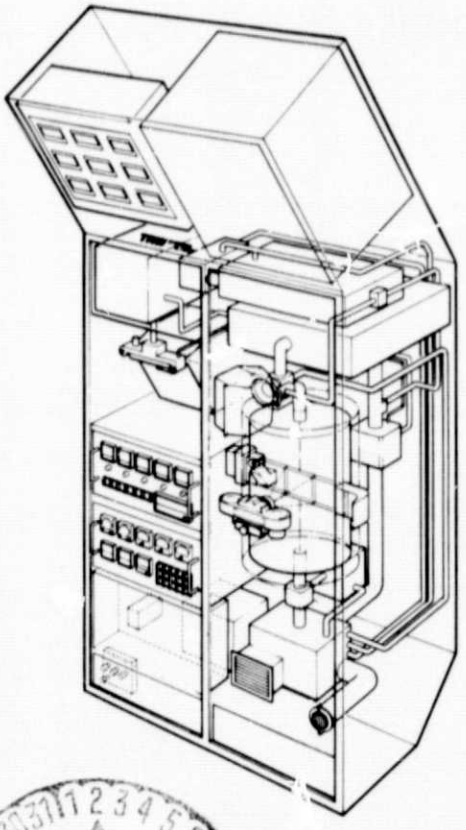
CONTRACT NAS8-31844

PHASE B-FINAL DEFINITION AND PRELIMINARY DESIGN STUDY FOR THE INITIAL ATMOSPHERIC CLOUD PHYSICS LABORATORY (ACPL) - A Spacelab Mission Payload

SUPPORTING RESEARCH AND TECHNOLOGY REPORT

PRELIMINARY ISSUE
DR-SE-243B



JUNE 1976

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama 35812

By

ACPL PROGRAM TEAM
O.W. Clausen, Program Manager

TRW
SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA 90278

INTRODUCTION

This document provides a preliminary identification of the Supporting Research and Technology (SR&T) necessary during the planned evolution of the Atmospheric Cloud Physics Laboratory (ACPL). None of the SR&T requirements identified pertain to the initial ACPL (scheduled for flight on Spacelab #1 in 1980); all requirements are for subsequent flights over its expected ten year lifetime.

Those components identified as requiring some SR&T work prior to inclusion on ACPL are:

- Aerosol Generation
- Ice Particle Detection and Analysis
- Vapor Cycle Refrigeration System for Space
- Particle Positioning System
- Analysis of Samples for Scavenging Experiments
- Controlled Expansion Chamber Recompression System
- Expansion Chamber Liquid Water Content (LWC) Measurement

A data sheet is included for each item, briefly justifying the need, giving general objectives for the proposed development effort and identifying approximate ACPL schedule requirements on the program. In most cases, the science objectives for the related ACPL experiments have not been fully established, and the requirements/objectives for the SR&T program are not specific. The first step in these cases is, of course, a quantitative definition of the science requirements associated with each SR&T item identified.

This document is submitted in partial fulfillment of Data Requirement SE-243B, Supporting Research and Technology Report. The final version of this document is due at contract completion.

TITLE: Aerosol Generation

JUSTIFICATION:

Stable and reproducible techniques to generate cloud forming aerosols coverir the range of sizes and materials of interest in cloud physics experi considered for ACPL are not available, even in ground-based laboratories where generator sizes and electrical power demands are not a factor. For ACPL where naturally generated aerosols are not present, and where size and power must be considered along with operation in a zero-gravity environment, development and ground verification of particle generators is very important.

For those general experiment classes identified thus far for ACPL, three aerosol generation requirements emerge:

- Very stable and reproducible aerosols for the high precision, warm cloud experiment (limited size range).
- Slightly less stable aerosols for other warm cloud experiments (broaden range of sizes and materials).
- Ice nuclei generators covering a range of sizes and materials.

Development of better techniques must be fully verified in ground operation prior to inclusion on ACPL; this also implies development of size measurement techniques with accuracy consistent with the requirements imposed on the generator.

All development should also be undertaken with proper considerations of ACPL allowable resources (mass, volume, electric power, thermal dissipation), and with expected ACPL operating environments.

GENERAL OBJECTIVES:

The general objectives of this SR&T effort are:

- To develop stable and reproducible aerosol generators which cover the range of sizes and materials of interest to experiment classes of interest to ACPL. The concepts are to be adaptable to the ACPL operating environment.
- To provide a thorough ground verification of each generator.
- To develop techniques/instruments for performance verification of the generators.

PROGRAM SCHEDULE REQUIREMENTS:

Stable generators are needed as soon as possible. Inclusion for the first laboratory update requires completion of the SR&T work by 1979.

TITLE: Ice Particle Detection and Analysis

JUSTIFICATION:

Performance of meaningful ice experiments on early ACPL missions implies inclusion of two important measurement techniques. First, there must be some way to discriminate, in real time, between water droplets and ice crystals in the Expansion Chamber. Second, there must also be some technique for reliably characterizing the ice nuclei. A possible approach to the latter is the Static Diffusion Ice (SDI) Chamber. Both techniques need ground-based development work prior to inclusion on a future ACPL, including thorough testing and ground verification.

A third implication of ice experiments is the collection and storage of ice crystals for earth analysis. The development work on this aspect of ice experiments should be preceded by a complete definition of science requirements for ice storage and return.

GENERAL OBJECTIVES:

The general objectives of this SR&T effort would be development and ground-based verification of the following ice particle detection and analysis techniques:

- Real time ice crystal/water droplet discriminator
- SDI for ice nuclei characterization
- Ice crystal collection and storage for ground evaluation.

PROGRAM SCHEDULE REQUIREMENTS:

Development work should be completed by 1979 to be included in the first ACPL update.

TITLE: Vapor Cycle Refrigeration System for Space

JUSTIFICATION:

Most experiment classes identified for ACPL require operation at temperatures below that available in Spacelab, which in turn, leads to a need for some form of refrigeration system. For ground-based operation, the vapor cycle compression system has long proven to be the most efficient and reliable. However, there are some development problems associated with operation of this cycle in a zero-gravity environment; e.g., control of a two phase mixture in the evaporator and condenser, and oil return to the compressor.

Techniques to meet these concerns need to be identified, studied and verified in ground-based laboratory testing. A development unit of a capacity consistent with ACPL requirements should be fabricated and its performance thoroughly demonstrated before inclusion in ACPL.

GENERAL OBJECTIVE:

The general objective of this SR&T effort is to develop a vapor cycle refrigeration system capable of operation in zero-gravity, and to demonstrate its operation.

PROGRAM SCHEDULE REQUIREMENTS:

As soon as possible. Integration in the first ACPL update implies completion of development work by 1979; integration in the second ACPL update by 1980.

TITLE: Particle Positioning System

JUSTIFICATION:

Many general experiment classes envisioned for later ACPL missions require long time observation of a single particle. This implies the positioning of the particle of interest in a carefully controlled space, and observation with an optical system capable of determining the changing particle size. This SR&T effort is directed to a study of the science requirements for a particle positioning system, and to definition and ground-based verification of such a system. The effort should appropriately consider Spacelab operational environments and available ACPL resources (mass, volume, power and heat rejection).

GENERAL OBJECTIVE:

The general objective of this SR&T effort is to develop and verify operation of a particle positioning system for ACPL consistent with operating environments and available resources.

PROGRAM SCHEDULE REQUIREMENTS:

Development work should be completed by 1979 for inclusion on the first ACPL update.

TITLE: Analysis of Samples for Scavenging Experiments

JUSTIFICATION:

Although the science requirements for ACPL scavenging experiments have not been defined, it is anticipated that some SR&T work will be necessary to properly analyze the resulting experiment samples. For example, if the experiment is to observe scavenging of small particles by larger particles, it will likely be necessary, at the end of the expansion, to collect the droplets and to determine how many large nuclei scavenged how many small nuclei. Techniques for doing this in a zero-gravity environment need to be developed and demonstrated prior to inclusion on ACPL.

GENERAL OBJECTIVES:

The general objectives of this SR&T effort are:

- To define the sample analysis requirements for potential ACPL scavenging experiments.
- To develop techniques to perform these sample analyses which are compatible with Spacelab operational environments and available resources.

PROGRAM SCHEDULE REQUIREMENTS:

Integration on the second ACPL update would require completion of development work by 1980.

ATMOSPHERIC CLOUD PHYSICS LABORATORY
SUPPORTING RESEARCH & TECHNOLOGY

TITLE: Controlled Expansion Chamber Recompression System

JUSTIFICATION:

The Expansion Chamber system envisioned for the initial ACPL has fixed walls and achieves an expansion by withdrawing air from within the chamber with an expansion unit. To perform memory experiments, it is desirous to stop the expansion at some point, to recompress and then re-expand to observe differences from the initial expansion. The quality of the experiment is degraded if the air re-introduced in the compression process is in any way different (e.g., particles, water vapor mixing ratio, temperature, pressure, etc.) from that already in the chamber. There seems almost no way not to introduce significant changes in the aerosol and droplet-laden air with the withdrawal system described above. Another approach is to physically expand the chamber walls; that introduces some obvious engineering difficulties that need development work prior to inclusion in ACPL. Limitations of the ACPL operating environments and available resources should be considered in the development of a controlled Expansion Chamber recompression system.

GENERAL OBJECTIVES:

The general objectives of this SR&T effort are:

- To identify science requirements associated with precision memory experiments.
- To study practical recompression approaches which meet these requirements.
- To develop and verify in ground testing, the selected approach.

PROGRAM SCHEDULE REQUIREMENTS:

Integration in the second ACPL update implies completion of the development work by 1980.

TITLE: Expansion Chamber Liquid Water Content (LWC) Measurement

JUSTIFICATION:

Accurate modeling of the expansion process and resulting droplet formation in an ACPL warm cloud experiment requires, in addition to temperature, pressure, water vapor mixing ratio and particle characteristics, knowledge of the liquid water content in the chamber at any instant in time. The most precise warm cloud experiment necessitates this information in real time so the expansion rate can be suitably altered. Ground-based techniques to accomplish this measurement are under extensive study, but have not yet been perfected.

An interim approach still of scientific value is to provide a non-real time measure of LWC which can then be utilized in analyzing the results of a particular experiment. It appears, for example, that laser holography can resolve particles in the size range of interest for ACPL warm cloud experiments. The difficulty appears to be able to measure the size from the hologram.

GENERAL OBJECTIVES:

The general objectives of this SR&T effort are:

- To develop and verify in ground testing non-real time techniques to determine liquid water content during the warm cloud expansion process which are compatible with ACPL operational environments and available resources.
- To develop real time LWC measurement techniques.

PROGRAM SCHEDULE REQUIREMENTS:

Integration in the third ACPL update requires development work to be completed by 1981.